

Testimony of David Garman
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U.S. Department of Energy
regarding the
Hydrogen Fuel and FreedomCAR Initiatives
before the
Committee on Science
U.S. House of Representatives
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Mr. Chairman, Members of the Committee, I appreciate the opportunity to testify today on the President's Hydrogen Fuel Initiative and FreedomCAR Partnership. My testimony will focus on the recent National Academy of Engineering and National Research Council report: *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*. I will also comment on the recent report of the American Physical Society, *The Hydrogen Initiative*.

At the outset I want to express the Department's appreciation for the valuable work performed by the National Research Council which conducted this very comprehensive study at our request. Its carefully considered recommendations and conclusions have already helped strengthen and focus DOE's hydrogen program and increased the likelihood of its success. The report will also help DOE better focus its research, priorities and funding, given the broad slate of potential hydrogen activities and technology directions. We are especially pleased to see the Committee's conclusion that "transition to hydrogen as a major fuel in the next 50 years could fundamentally transform the U.S. energy system, creating opportunities to increase energy security through the use of a variety of domestic energy sources for hydrogen production while reducing environmental impacts, including atmospheric CO₂ emissions and criteria pollutants."

Hydrogen Fuel Initiative

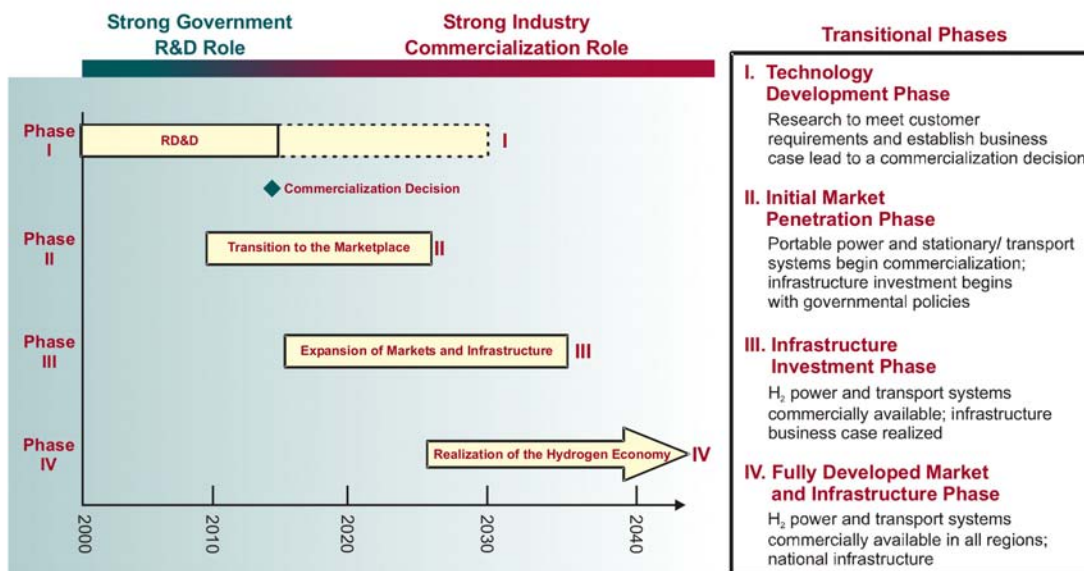
Mr. Chairman, it was a little more than one year ago that the President announced a pioneering plan to transform the Nation's energy future from one dependent on foreign petroleum to one that utilizes the most abundant element in the universe – hydrogen. This solution holds the potential to provide virtually limitless clean, safe, secure, affordable, and reliable energy from domestic resources. To achieve this vision, the President proposed that the federal government significantly increase its investment in hydrogen infrastructure research and development (R&D), including hydrogen production, storage, and delivery technologies, as well as fuel cells, with the goal of enabling an industry decision by 2015 to commercialize hydrogen fuel cell vehicles.

This vision is now shared around the world. Last fall, at the urging of Secretary Abraham, 15 nations, including the United States and the European Union, agreed to establish the International Partnership for the Hydrogen Economy (IPHE). The IPHE is providing a mechanism to efficiently organize and coordinate multinational research, development and deployment programs that advance the transition to a global hydrogen economy. The IPHE partners represent more than 85 percent of the world's gross domestic product and two thirds of the world's energy consumption and greenhouse gas emissions.

At a March 5, 2003 hearing before this Committee, I described in detail DOE's plans to help turn the concept of a hydrogen-based economy into reality. At the time we described how we would integrate our ongoing and future hydrogen R&D activities into a focused Hydrogen Program, and how we would integrate technology for hydrogen production (from fossil, nuclear, and renewable resources), infrastructure development (including delivery and storage), fuel cells, and other technologies. We also described how we would coordinate hydrogen activities within DOE and among the federal agencies to achieve the technical milestones on the road to a hydrogen economy.

We discussed the challenges to be faced and how we believed they could be met. We said that achieving a hydrogen-based economy would require a combination of technological breakthroughs, market acceptance, and large investments in a national hydrogen energy infrastructure. We knew that success would not happen overnight, or even over years, but rather over decades. We knew it would be a long-term process that would phase hydrogen in as the technologies and their markets are ready, and that success would require that the technologies to utilize hydrogen fuel and the availability of hydrogen fuel occur simultaneously.

Also at that hearing, I presented the following timeline:



As you can see, the timeline shows that we won't realize the full potential of a hydrogen economy for several decades. Phase I technology development will lead to a commercialization decision by industry only if government-sponsored and private research is successful in meeting customer requirements and in establishing a business case that can convince industry to invest. If industry makes a positive commercialization decision, we will be ready to take the next steps toward realizing the full potential of the hydrogen economy, a process that will evolve over several decades, and may include policy options other than research to catalyze infrastructure investment. The impact of hydrogen fuel cell vehicles will depend on how quickly the market introduces the new vehicles, the availability of production and delivery infrastructure, and the

time it takes for a new fleet of hydrogen vehicles to replace the existing inventory of conventional vehicles.

Our focus today is the research and development to overcome the technical barriers associated with hydrogen and fuel cell technologies -- including lowering the cost of hydrogen production and fuel cell technologies, improving hydrogen storage systems, and developing codes and standards for hydrogen handling and use. The Department has requested \$227 million in its FY 2005 budget request to support the Hydrogen Fuel Initiative. In addition, the Department of Transportation requested about \$1.0 million.

Over the past year our progress has increased confidence that the 2015 goal is realistic and attainable. For example:

- Significant technical progress has been made in reducing the cost of hydrogen production. We have verified the ability to produce hydrogen from natural gas at \$3.60 per gallon of gasoline equivalent from an integrated hydrogen refueling station that co-produces electricity from a stationary fuel cell. This meets our 2003 interim milestone.
- In the very near future, we will announce selections from two major competitive solicitations. The first is our hydrogen storage "Grand Challenge." Novel approaches, beyond pressurized tanks, are needed in the long term to provide the greater than 300 mile range that consumers expect. Our new hydrogen storage selections have established three "Centers of Excellence" where each center is composed of a national lab teamed with seven or eight universities to research novel materials for hydrogen storage.
- The second major solicitation is for our national fuel cell vehicle and hydrogen infrastructure "learning" demonstration. This "demonstration" is an extension of our research and will provide us the necessary data to focus our research on the most difficult technical barriers and safety issues, as well as help us identify vehicle-infrastructure interface issues that need to be worked out collectively by the government, automotive manufacturers and energy industry.
- In the coming months, we will also be announcing winners to our hydrogen production and delivery research solicitation.

To track the progress of our research, the Department and its industry partners jointly develop performance-based technical and cost milestones that reflect customer requirements and the business case needed for industry to invest. Our newly released Hydrogen Posture Plan details the Department's overall integrated plan, identifies key technology milestones, and includes timelines that provide clear and quantifiable measures to track and demonstrate progress. We do not believe that these milestones are unrealistic. They are, however, intentionally aggressive so that we "set the bar high" to try to stimulate revolutionary ideas in research. Having said that, we plan to evaluate all of the milestones based on the National Academies' report. Indeed, the Hydrogen Posture Plan already takes into account many of the report's comments.

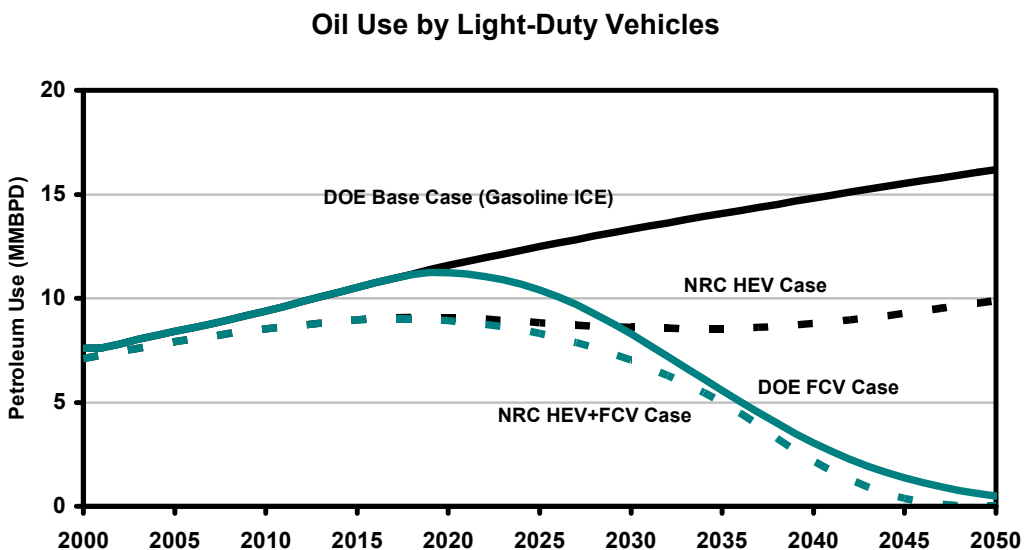
Our focus on hydrogen fuel cell vehicles does not come at the expense of support for conservation and gasoline hybrid vehicles as short-term strategy for reducing oil use, criteria

pollutants and greenhouse gas emissions. Under the FreedomCAR Partnership, in addition to research on fuel cells, the Department requests \$91 million to continue research to develop advanced, affordable hybrid component technologies. These technologies include energy storage devices, power electronics, lightweight materials, advanced combustion engines, and other technologies that have application for the gasoline hybrids of today, the fuel cell vehicles of tomorrow, or in many cases, both. The Department continues to implement robust programs in support of wind turbines, solar photovoltaic technology, Generation IV nuclear power systems, and solid state lighting, and many other energy technology program areas.

However, as the National Academies' report notes, it will take a revolutionary approach like hydrogen fuel cells to provide the fundamental change that will allow us to be completely independent of oil and free of carbon in the tailpipe. Incremental changes available in the near term will not overcome the increasing demands for a limited supply of oil.

This is demonstrated in the chart titled "Oil Use by Light Duty Vehicles." The National Academies' National Research Council report shows a case where gasoline hybrid electric vehicles (HEV), the "NRC HEV Case," penetrate the market. As you can see, under this scenario, petroleum use stays constant at best and we don't reduce our vulnerabilities associated with importing foreign oil since domestic production stays constant. When you consider the growth of petroleum use around the world, especially in developing countries, there will be an even greater demand for limited supplies.

Fuel cell vehicle (FCV) market penetration scenarios developed by DOE and the National Academies' National Research Council (NRC) are similar. As shown in the chart, the petroleum use from the "DOE FCV" case is very similar to the "NRC HEV + FCV" case. This analysis also shows that in the long-term, increased fuel economy alone will not even reduce the amount of oil use compared to today's level. Simply put, if we are going to significantly reduce our dependence on foreign oil, we need to substitute for petroleum.



Response to National Academies Report

DOE fully recognized the complexity and uncertainties involved in a transition to a hydrogen economy, and requested the National Academies to conduct an independent review of our hydrogen production and infrastructure options. We requested assistance in two major areas: (1) assessing strategies for hydrogen production from domestic resources in near-, mid-, and long-term; and (2) reviewing the Department's current research plans and making recommendations on research strategies.

Last April, the committee provided us with four interim recommendations, which we acted upon immediately. They are:

1. **The Department should establish an independent systems engineering and analysis group.** In response to this recommendation we conducted a nationwide recruiting effort and hired a lead systems integrator. The systems integrator has been tasked to develop a model to assess the impact of various technology pathways, identify key cost drivers and technological gaps, and assist in prioritization of R&D directions. A portion of the increase in the FY 2005 budget request will be used to create this capability.
2. **The Department should give exploratory and fundamental research additional budgetary emphasis.** As a result of this recommendation, the DOE Office of Science is now directly involved in supporting the President's Hydrogen Fuel Initiative. Last May, the Office of Science hosted a workshop to identify the basic research needs for a hydrogen economy. The Office of Science created and filled a position for Senior Advisor for Applied Energy Programs. This person has a broad knowledge of the Science R&D programs at the National Laboratories, and helps the applied programs in their search for technological breakthroughs. The Department's FY 2005 budget request includes \$29 million for the Office of Science to conduct basic research in hydrogen production, storage and use.
3. **DOE should make a significant effort to address safety issues.** In response, we developed guidelines for safety plans to be carried out on all projects and established a safety review panel to evaluate implementation of these plans. In addition, the Department's FY 2005 budget request includes a three-fold increase in funding for safety-related research. We have also worked closely with the Department of Transportation, the National Institute of Science and Technology, and other organizations to define roles and responsibilities for the research and development of hydrogen codes and standards to enable safe use of hydrogen.
4. **DOE should integrate hydrogen R&D efforts across the applied energy programs, the Office of Science, and appropriate industry partners.** The Department's Hydrogen Posture Plan integrates the hydrogen activities supporting the President's Hydrogen Fuel Initiative across the renewable energy, fossil energy, science, and nuclear energy offices. This plan lays the foundation for a coordinated response to the President's goal for accelerated research on critical path hydrogen and fuel cell technologies. We have also expanded our existing FreedomCAR

Partnership to include major energy companies (ExxonMobil, ConocoPhillips, ChevronTexaco, BP and Shell) along with all three major U.S. auto manufacturers.

The final report of the committee presented us with two main themes:

Theme 1: There should be a shift away from some development areas towards more exploratory work.

The Department has already begun shifting towards more exploratory research. A good example is in the hydrogen storage area, where we are establishing three “Centers of Excellence” led by national laboratories along with multiple university and industry partners. This could be a model for “expert” centers focusing on other priority research areas such as fuel cell costs and durability, distributed hydrogen production costs and efficiency, systems analysis for hydrogen delivery, and renewable hydrogen production methods such as photobiological, photo-electrochemical (direct solar conversion) and thermochemical (splitting water with heat processes).

The Department’s mix of funding according to OMB circular A-11 for the FY 2005 budget request is as follows:

Basic Research:	12.9%
Applied Research:	42.5%
Development:	29.2%
Demonstration:	13.4%
Deployment:	2.0%

This mix reflects our shift towards more exploratory R&D in the hydrogen storage area. We are currently evaluating our fuel cell cost and durability research to see if more exploratory R&D is appropriate. I want to caution everyone that “exploratory” R&D is not synonymous with “basic” R&D. We believe the committee is recommending that we shift away from some development work that industry is capable of doing.

Theme 2: The hydrogen transition may best be accomplished through distributed production at fueling sites, from natural gas reforming or water electrolysis from wind or solar energy. The committee recommends increased R&D investments on these distributed hydrogen technologies, which will supply hydrogen for the early transitional period, and suggests allowing the long-term hydrogen economy to evolve.

Based on this recommendation, the Department will increase its focus on exploratory research to reduce costs and increase efficiency of water electrolysis and distributed natural gas reforming. In this recommendation, we believe the National Academies’ committee is telling us not to over manage the long term, that the longer-term hydrogen economy should “evolve” through greater emphasis on breakthroughs in technologies with longer time horizons for commercial application, such as carbon capture and sequestration to enable coal as a long-term resource, photoelectrochemical, photobiological, and thermochemical methods.

In keeping with this recommendation, the Office of Science is now established as a direct participant in the President’s initiative and we are directing our applied research into more

exploratory technologies. As mentioned earlier, our hydrogen storage “Grand Challenge” will create three Centers of Excellence involving federal laboratories, universities, and private industry. We agree with the need to support exploratory research and will shift our program activities to a more basic and exploratory nature, as appropriate.

Response to American Physical Society Report

The American Physical Society report on hydrogen calls for more spending on basic research and contends that demonstrations are premature. On the second part of this recommendation, DOE along with its industry partners believe there is a clear need for such “learning” demonstrations. These demonstrations serve as extensions of our research, and are aimed at obtaining performance and durability data in real world environments. I want to stress that these are not demonstrations geared toward commercialization. There is no formula that can tell us that we have achieved a certain percentage of our target and that it is now time to conduct a demonstration to close the final gap. At this stage in the development, technology costs are reduced through research breakthroughs in materials, performance, and manufacturing technology, not “commercial” demonstrations.

Learning demonstrations, however, will provide improved understanding of the impact of various climatic conditions on fuel cell performance and durability. Such data are crucial to resolving system barriers such as water and heat management within the fuel cell. At the conclusion of the 5-year demonstration program, the pre-established targets of 2,000 hours durability, 250 mile range and \$3.00 per gallon gasoline equivalent are to be met by industry. This demonstration effort will give us the statistical evidence that adequate progress is being made to meet the 2015 criteria of 5,000 hours durability, 300 mile range and \$1.50-2.00 per gallon gasoline equivalent. These demonstrations will provide accelerated data that we will need to refocus our future R&D, and will provide the hard data needed to make difficult decisions should we experience a lack of research progress.

In a hydrogen economy, we will need multiple and complex interfaces among production, delivery, storage, conversion and end-use. Auto manufacturers, energy companies, and component suppliers will need to work together over the next several years to resolve such issues as the vehicle-infrastructure refueling interfaces. If we are going to make the huge transformation to a hydrogen energy system, it will be private companies, not the government, to make the investment and build the automotive manufacturing infrastructure and hydrogen production and delivery infrastructure. This learning demonstration will reveal potential solutions to overcoming technical and economic hurdles to building infrastructure

The learning demonstration will also reveal potential safety issues and open a door to cooperation with local jurisdictions on uniform codes and standards. In summary, we believe that limited learning demonstrations, utilizing less than 15 percent of the overall hydrogen program budget and with industry cost-sharing at a 1:1 ratio, will provide us with the practical experience and critical data to ensure that our applied and exploratory research efforts are focused on the right problems.

Conclusion

Mr. Chairman, all the panelists here today will agree that achieving the vision of the hydrogen energy future is a great challenge. It will require careful planning and coordination, public education, technology development, and substantial public and private investments. It will require a broad political consensus and a bipartisan approach. Most of all, it will take leadership and resolve. By being bold and innovative, we can change the way we do business here in America; we can change our dependence upon foreign sources of energy; we can help with the quality of the air; and we can make a fundamental difference for the future of our children. This Committee in particular has been instrumental in providing that kind of leadership over the years, and we look forward to continuing this dialogue in the months and years ahead.

We at the Department of Energy welcome the challenge and opportunity to play a vital role in this Nation's energy future and to support our national security in such a fundamental way. This completes my prepared statement. I would be happy to answer any questions you may have.